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**Federal Aviation
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Methodology to Categorize the Noise Efficiency of Air Tour Aircraft in GCNP

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Introduction

On July 31, 1996, Federal Aviation Administration (FAA) published in the Federal Register a Notice of Proposed Rulemaking (NPRM), "Special Flight Rules in the Vicinity of Grand Canyon National Park." In the notice (Notice No. 96-11), FAA proposed to amend part 93 of the Federal Aviation Regulations by adding a new subpart. Specifically, FAA proposed to modify the dimensions of the special flight rules area over Grand Canyon National Park (GCNP) to establish new and modify existing flight-free zones; and establish reporting requirements for commercial sightseeing companies operating at the park. The FAA also solicited comments and suggestions on alternative actions to protect the resources of GCNP from the adverse effects of aircraft noise exposure. Some of the ideas proposed in the notice included variable or fixed curfews; caps on operations, aircraft, or tour operators; and the use of quieter tour aircraft. This paper addresses the interest in quiet aircraft incentives and offers criteria to use in identifying and selecting the quietest aircraft.

In response to comments in the docket (Docket No. 28537) and those made at public hearings, FAA redoubled its efforts to develop concepts that would provide incentives for tour operators to invest in the best available noise abatement technology. Traditionally, the FAA uses its regulatory authority to impose more stringent national noise standards when it has been determined to be appropriate. By law when deciding further noise stringency, FAA must ascertain whether the proposal is technologically feasible, economically reasonable, and appropriate to aircraft type. Based upon a joint FAA/NASA research report to Congress on quiet technology[1] and earlier work prepared for the third meeting of the Committee on Aviation Environmental Protection (CAEP) under the International Civil Aviation Organization (ICAO), the FAA determined that the imposition of new national and international noise standards for propeller-driven small airplanes and helicopters is not appropriate at this time. While there is ongoing research by the Federal government to identify future noise abatement technology, current aircraft designs already incorporate most of the available technology within economic reasonableness. At GCNP, there are substantive differences in the noise characteristics of the aircraft in use. Therefore, FAA looked to non-traditional

[1] Report of the FAA and NASA to the U.S. Congress Pursuant to Section 308 of the FAA Authroization Act of 1994, "Quiet Aircraft Technology for Propeller-driven Airplanes and Rotorcraft," June 1996.

concepts that could offer some incentive for tour operators to improve the GCNP situation.

Noise Efficiency Concept

One theme expressed by some commenters was that the use of quieter, larger aircraft would provide two-fold benefits in reducing noise of each operation and reducing the number of operations to carry the same number of passengers. This theme fits in nicely with the FAA's general policy of using cumulative aircraft noise as an appropriate measure of the potential impact as it accounts for the number of flights and intensity of their noise. The FAA began to explore noise efficiency concepts as an incentive for operators to utilize aircraft equipped with the best available noise abatement technology in the park. The following attributes were used in judging potential concepts:

- Is based on aircraft noise certification (14 CFR part 36)
- Judges fixed- and rotary-wing aircraft on a common basis
- Correlates with aircraft performance and operation at GCNP
- Offers basis for incentives
- Is manageable

In addition to these attributes the concept must be shown to be economically reasonable.

Links to Aircraft Noise Certification

Levels obtained from aircraft noise certification represent the highest quality of data available. The flight tests are conducted under controlled conditions with an FAA representative or designee in attendance to witness the test setup and test activities. Data obtained during these tests are corrected to standard reference conditions as prescribed in 14 CFR part 36. FAA publishes these levels in Advisory Circular (AC) 36-1, "Noise Levels for U.S. Certificated and Foreign Aircraft." The current version of this AC is 36-1F dated 6/5/92. Unfortunately there is no single method applicable to all aircraft for determining the certificated noise level. Depending on date of application for type certificate and whether the aircraft is a helicopter or airplane, the noise level could have been obtained from one of 4 different tests.

Appendix F of 14 CFR part 36 which went into effect in January 1975 prescribes the measurement procedures for propeller-driven small airplanes. The test involves a level flight at highest normal power setting at 1000 ft. over the microphone. Noise is measured in maximum A-weighted Sound Level (L_{Amax}). On December 22, 1988, Appendix G of 14 CFR part 36 superseded Appendix F. The Appendix G test involves a takeoff at maximum continuous power and the microphone is located 8200 ft. from start of takeoff roll. Noise is measured in L_{Amax}. Appendix H of 14 CFR part 36 which went into effect in February 1988 prescribes the measurement procedures for helicopters. The test involves 3 flight regimes, takeoff, approach, and level flyover. The level flyover is conducted at 492 ft. over the microphone at maximum continuous RPM. Noise is measured in Effective Perceived Noise Level (EPNL). Appendix J of 14 CFR part 36 which went into effect in September 1992 prescribes an alternative measurement procedure for helicopters weighing not more than 6,000 lb. The test involves a level flyover. The level flyover is conducted at 492 ft. over the microphone at maximum continuous RPM. Noise is measured in Sound Exposure Level (SEL).

With measurements taken for different flight operations, at 3 different altitudes, and in 3 different units of noise, it is not possible to directly compare Appendix F, G, H, and J noise levels. However, FAA has developed a procedure for: (1) extrapolating from the controlled conditions of a certification test to the operating conditions at GCNP and (2) converting levels to a common noise unit, thus making it possible to judge fixed- and rotary-wing aircraft on a common basis under conditions that pertain to air tour operations over GCNP. The subsequent sections describe the procedures used to extrapolate from certification conditions to GCNP conditions.

The distance between air tour flight routes on Dragon Corridor and Hermit's Rest Overlook was selected as a representative reference point for comparisons. The choice of Hermit's Rest is immaterial to the outcome. Any noise sensitive location in GCNP could have been selected. The extrapolation procedures would have been the same. The resultant ranking of airplane and helicopter noise levels as shown in a later section would have been essentially the same. SEL was selected as the common noise unit. SEL is a basic building block in calculating Equivalent Sound Level (L_{eq}) which is the measure of cumulative noise that FAA is using to assess noise impacts in GCNP. L_{eq} is the most common method used to quantify time-varying noises. The Federal government uses a form of equivalent sound level, Day Night Sound Level (DNL), to quantify aircraft noise exposure in the vicinity of airports.

This part of the study found that it is possible to extrapolate from the certification conditions of Appendices F, H, and J to produce a consistent set of noise levels representing GCNP operating conditions. However, no reliable procedure was found for Appendix G. As described in a later section, other accommodations were made to enable the development of noise efficiency criteria for airplanes with only Appendix G noise levels.

Extrapolation of Appendix F Noise Levels

This exercise developed an estimate of Hermit's Rest SEL values based on 14 CFR part 36 propeller-driven small airplane certification levels. Accounting for all the factors, the adjustment to Appendix F level ranges between -12.2 and -6.6 dB depending on whether the airplane is turbine- or piston-powered.

The Appendix F tests are conducted with the airplane in a level flyover at a height of 1000 ft over the measuring station. The engine power setting is the highest power in the normal operating range in the aircraft flight manual (AFM). Appendix F also requires a correction applied to the measured noise level. The correction rewarded high performance airplanes and penalized low performance airplanes. In this study only the measured noise levels are used in extrapolating the data to Hermit's Rest as level flyover is more representative of an air tour operation.

Sound waves are attenuated by two mechanisms as they travel through the air. The first mechanism is the spherical spreading. The acoustic energy is spread out from the source evenly (that is, spherically) at distances far away from the source. The rate of spreading is inversely proportional to the distance squared at approximately 6 dB per doubling of distance. 14 CFR part 36 refers to this formula in many places (for example, Appendix A section A36.11(d)). The spherical spreading is not frequency dependent.

The second mechanism is the atmospheric absorption which is the degradation of acoustic energy into some form of heat energy. In practice the rate of this type of attenuation is calculated using the formulations in SAE ARP 866A[2]. Atmospheric attenuation is a function of frequency unlike the spherical spreading.

A simple method was devised for an approximate atmospheric attenuation value. One-third octave spectra noise levels of six general aviation airplanes were published in the FAA report entitled "Noise Levels and Data Correction Analysis for Several General Aviation Aircraft," FAA-EE-80-26, and were used for this task. Six aircraft from the report were grouped into two categories according to their engine type and size. The first category consists of three piston powered airplanes; Piper PA31, Cessna 172 and Cessna 421 (Figure 1). The second category contains two turbine-powered airplanes; Convair 580, Rockwell 690 and one piston-powered airplane Rockwell 500S (Figure 2).

All six spectra were attenuated to Hermit's Rest by using the above mentioned SAE ARP 866A method. The spherical spreading was accounted for by the following formula:

$$L_{HR} = L_{ref} + 20 \log(d_{ref}/d_{HR})$$

where:

L_{HR} is sound level at Hermit's Rest

L_{ref} is sound level at the reference location

d_{ref} is distance between the airplane and the reference location

d_{HR} is distance between the airplane and Hermit's Rest

The overall sound pressure levels of each spectrum before and after attenuation were calculated. The differences between the before and after levels are the reductions in overall sound pressure level which are caused by the spherical spreading and atmospheric attenuation.

[2] "Standard Values of a Atmospheric Absorption as a Function of Temperature and Humidity," Aerospace Recommended Practice ARP 866A, Society of Automotive Engineers, Inc. (1975).

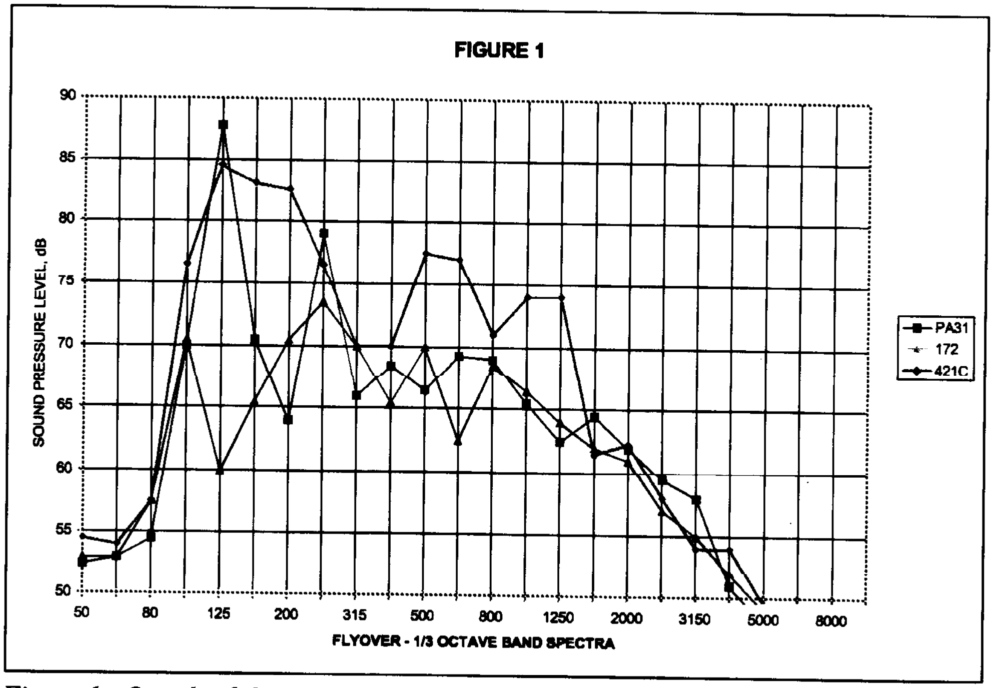

Figure 1. One-third Octave Noise Spectra for Examples of Piston-powered Airplanes

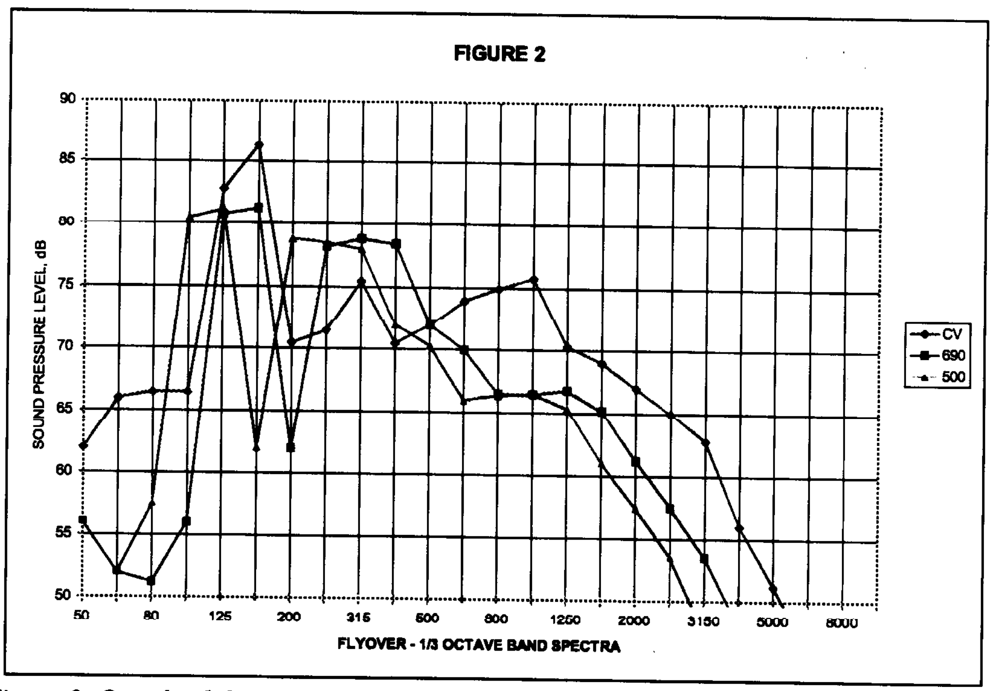

Figure 2. One-third Octave Noise Spectra for Examples of Turbine-powered Airplanes

Example calculation: Piper PA 31

The measured spectrum (upper curve of Figure 3) was first extrapolated to 9300 ft distance by applying both corrections:

1. Spherical spreading = 20 $\log_{10}$ {1000/9300} = -19.8 dB
2. Atmospheric attenuation by SAE ARP 866A

The resulting curve is the extrapolated spectrum (lower curve of Figure 3). The difference between the overall levels of the two spectra is the expected attenuation at Hermit's Rest. In this example, the attenuation is 77.6 - 53.9 = 23.7 dB of which 19.4 dB is due to spherical spreading and 4.2 dB is due to atmospheric absorption.

The same calculation was repeated for five other airplanes

	Total attenuation (dB)	Spherical spreading (dB)	Atmospheric attenuation (dB)
Piper PA31	23.7	19.4	4.3
Cessna 172	27.0	19.4	7.6
Cessna 421	25.8	19.4	6.4
Average	**25.5**		
Convair 580	26.8	19.4	7.4
Rockwell 690	24.3	19.4	4.9
Rockwell 500S	23.6	19.4	4.2
Average	**24.9**		

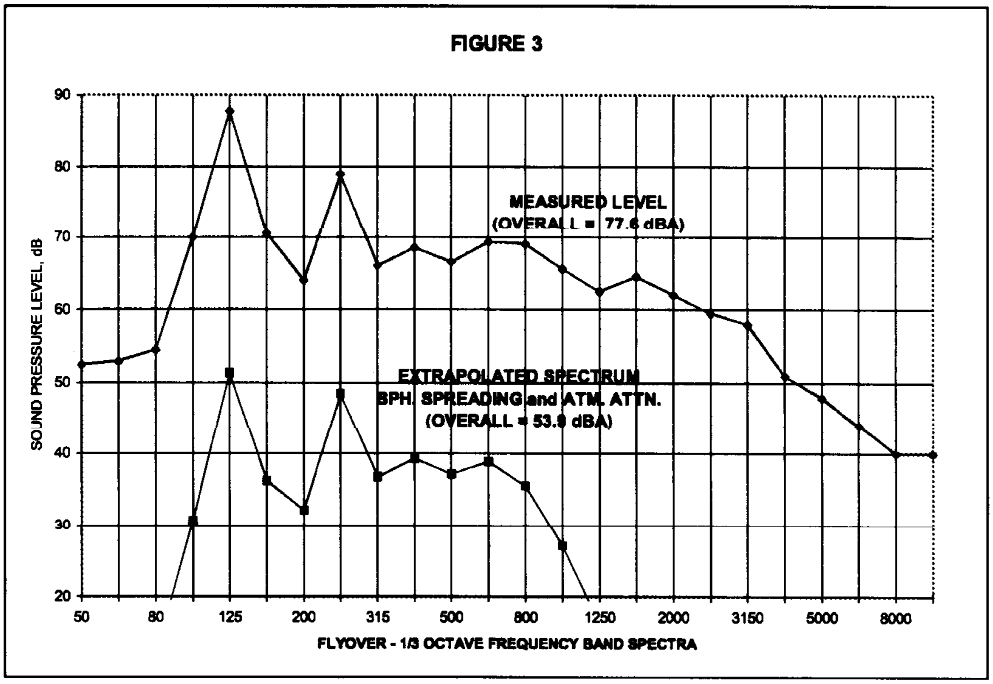

Figure 3. Examples of Measured and Extrapolated One-third Octave Spectra

As determined by this study, the average attenuation for piston-powered airplanes is 25.5 dB. The average attenuation for turbine-powered airplanes is 24.9 dB. These values are applied to Appendix F noise levels as shown in the "NOISE MEAS." column of Appendix 7 of AC 36-1F to derive a noise level that could be received at Hermit's Rest. That value is then converted to SEL.

The conversion to SEL was done using the aircraft noise database found in the Integrated Noise Model (INM). The INM database contains noise-power distance tables in L_{Amax}, SEL, and EPNL for a wide variety of aircraft types including some representative piston and turbine powered small propeller-driven airplanes. Analysis of the INM noise data at a slant distance of 9300 ft (to Hermit's Rest) shows that the difference between SEL and L_{Amax} ranges between 12.7 and 18.9 dB. The appropriate metric conversion value is then applied to the specific, extrapolated L_{Amax} value to obtain an SEL estimate for that airplane at Hermit's Rest.

Extrapolation Procedures for Appendices H and J

The extrapolation techniques used to estimate distant helicopter noise levels from helicopter certification levels include adjustments to certification data to account for the following:

- spherical spreading (SS)
- atmospheric attenuation (AA)
- duration (DUR)
- directivity (DIR)
- metric (EPNL vs. SEL) (MET)
- microphone position averaging (MIK)

Empirical data were used to develop most of the foregoing adjustments. The data used were from helicopters with maximum takeoff weight (MTOW) up to 6,000 lb. The sign convention is such that the adjustment value is the value to be algebraically added to the certification level to estimate the long range noise level.

This exercise developed an estimate of Hermit's Rest SEL values (SEL_{HR}) from 14 CFR part 36 helicopter certification levels. Accounting for all the factors, the adjustment to Appendix J level that would produce the desired Hermit's Rest SEL value is -21.7 dB. A similar adjustment for Appendix H noise level is -24.5 dB. The equations for these adjustments are as follows:

For an Appendix J certification level (SEL_J):

$$SEL_{HR} = SEL_J + SS + AA + DUR + DIR$$

For an Appendix H flyover certification level (SEL_H):

$$SEL_{HR} = SEL_H + SS + AA + DUR + DIR + MET + MIK$$

where:

Spherical spreading (SS):

The classical 6 dB per doubling of distance was used; thus:

$$SS = 20 \times LOG_{10}(d_{ref}/d_x)$$

where d_{ref} is 492 ft and extrapolated distance (d_x) is the desired slant range.

For the immediate analysis in question, d_x is 9300 ft; thus

$$SS = 20 \times LOG_{10}(492/9300)$$

SS = -25.5 dB

Atmospheric attenuation (AA):

In order to calculate the effects of atmospheric absorption over the desired propagation distance (d_x), it is necessary to know the spectrum shape (relative noise level vs frequency) for the helicopter acoustic signal in question. The research data available for helicopter spectra are in the form of one-third octave band levels in ANSI band numbers 17 through 40 inclusively (24 bands). However, for the GCNP exercise, it is assumed at this point that the original source of available data that is to be used in the exercise is 14 CFR part 36 aircraft noise certification levels as published in the flight manual. Details of the measured and analytical data used to arrive at the certification level is normally proprietary and as such, are not available for use by an applicant in demonstrating compliance with a possible future noise operating regulation for GCNP. Thus, it is necessary to develop a representative one-third octave spectrum for use in this analysis. The representative spectrum used in this exercise is a composite spectrum developed from research studies of several light turbine-powered helicopters. The composite is the same spectrum used in establishing the allowable test window for Appendix J of 14 CFR part 36 and Chapter 11 of the ICAO standards. The composite was developed by using individual helicopter flyover spectra from the centerline microphone position at the time of maximum tone-corrected perceived noise levels. The individual spectra were normalized to an overall sound pressure level of 80 dB and the resulting normalized spectra were algebraically averaged to arrive at the composite values.

For this exercise, the atmosphere is assumed to be at 77 degrees F and 70 % relative humidity (RH) at all points along the propagation path. The atmospheric absorption rates at 77F/70%RH for each of the 24 one-third octave bands were taken from SAE ARP 866A. Each one-third octave band of the composite spectrum was adjusted by the following expression in order to account for the desired propagation distance:

$$(d_x/1000) \times (-1)(\alpha_i)$$

where d_x is the desired extrapolation distance and α_I is the absorption rate in dB/1000ft for the (i)th one-third octave band. For the exercise of interest, at a propagation distance of 9300 ft, the effect of atmospheric absorption on the A-weighted composite spectrum is:

AA = -7.7 dB

Duration (DUR):
The effect of increased duration on the integrated metric SEL is accounted for by the adjustment:

$$DUR = -7.5 \times LOG_{10}(d_{ref}/d_x);$$

where d_{ref} is 492 ft. and d_x is 9300 ft. for this exercise.
Thus, for this exercise:

$$\boxed{DUR = +9.6\ dB}$$

Directivity (DIR):
An adjustment is required that would convert a centerline microphone noise level to an equivalent sideline noise level in order to better estimate the propagation under the geometric conditions of the GCNP exercise. Again, an empirical assessment was made on available certification-type research data to establish a relationship between the centerline data point (which is the only data available from an Appendix J certification) and the noise level experienced at the certification sideline microphone location (492 ft. from the flight track; geometrically a 45 degree "lookdown" angle from the horizon from the aircraft's perspective). The analysis of the data shows that, on average, for the helicopters examined there is no difference in the SEL measured at the sideline microphone position versus the SEL measured at the centerline position. However, the propagation distance from the helicopter to the sideline measurement point is longer than distance from the helicopter to the centerline measurement point (when the helicopter is directly overhead of the microphone array, that is, 696 ft. vs. 492 ft.). The data point of interest is the equivalent SEL value at 492 ft. propagating along the 45 degree path from the helicopter to the ground. Thus it is necessary to convert the sideline SEL value at 696 ft. to a value at 492 ft. Taking spherical spreading and duration into account via the previously discussed adjustments, the adjustment that is needed to adjust the centerline SEL value to account for directivity effects (at a 45 degree angle) is as follows:

$$DIR = 20 \times LOG_{10}(696/492) -7.5 \times LOG_{10}(696/492)$$

$$\boxed{DIR = +1.9\ dB}$$

The foregoing adjustments are those necessary to adjust an Appendix J noise certification level to an estimated "Hermit's Rest" value (side angle; 9300 ft.distance). The next two adjustments are those necessary to convert an Appendix H certification level for level flyover (three-mike average; EPNL metric) to an estimated Appendix J certification level.

Metric (MET):
FAA research data, which was used in the development of Appendix J, shows, on average, for the level flyover procedure, the centerline EPNL is 3.3 dB greater than the SEL; thus to estimate the SEL from the EPNL, subtract 3.3 dB from the EPNL level as follows:

$$\boxed{MET = -3.3\ dB}$$

The value is valid only for the conditions and procedures specified in this exercise.

Microphone averaging (MIK):
Since, for certification, only an average of the levels from the three microphone positions is available in the public domain, it is necessary to estimate the centerline EPNL from the (averaged) certification level. For the ten light turbine helicopters examined, on average, the sideline mike levels are 84.96 and 84.88 dB and the center mike level is 85.64 dB. The average of the three mikes (which represents the available certification level) is 85.16 dB. Thus, to estimate the centerline mike level from the certification level, add 0.5 dB to the certification level; i.e.,

$$\boxed{MIK = +0.5\ dB}$$

The foregoing analysis is based on "averaged data." There is considerable variation in the data for the helicopters examined. Use of composite spectra and other "averaged values" may result in inaccuracies when used in the estimation of a noise level for a particular helicopter. Further, use of data adjustment procedures [such as -7.5 x LOG(d1/d2)] which were developed to correct data over relatively short off-reference distances, may introduce inaccuracies when used to extrapolate data over long propagation distances.

Noise Efficiency Measure

These extrapolation procedures for predicting noise levels applicable to Appendices F, H, and J of 14 CFR part 36 enables one to directly compare propeller-driven small airplanes and helicopters. There is no extrapolation procedure for Appendix G. The noise efficiency criterion for Appendix G noise levels was derived by a method that is explained later. In keeping with the theme of developing a noise efficiency concept, the extrapolated noise levels were examined as a function of the number of passenger seats in the air tour aircraft operating at GCNP. Since the principal business of these aircraft is to carry sightseers over the park, the number of passenger seats is a logical production or efficiency factor. Figure 4 shows noise levels of many of the current air tour aircraft against the number of passenger seats in the aircraft. The aircraft identities are defined in Table 1. Figure 4 becomes the basis for developing noise efficiency criteria based on extrapolated SEL as a function of the number of passenger seats.

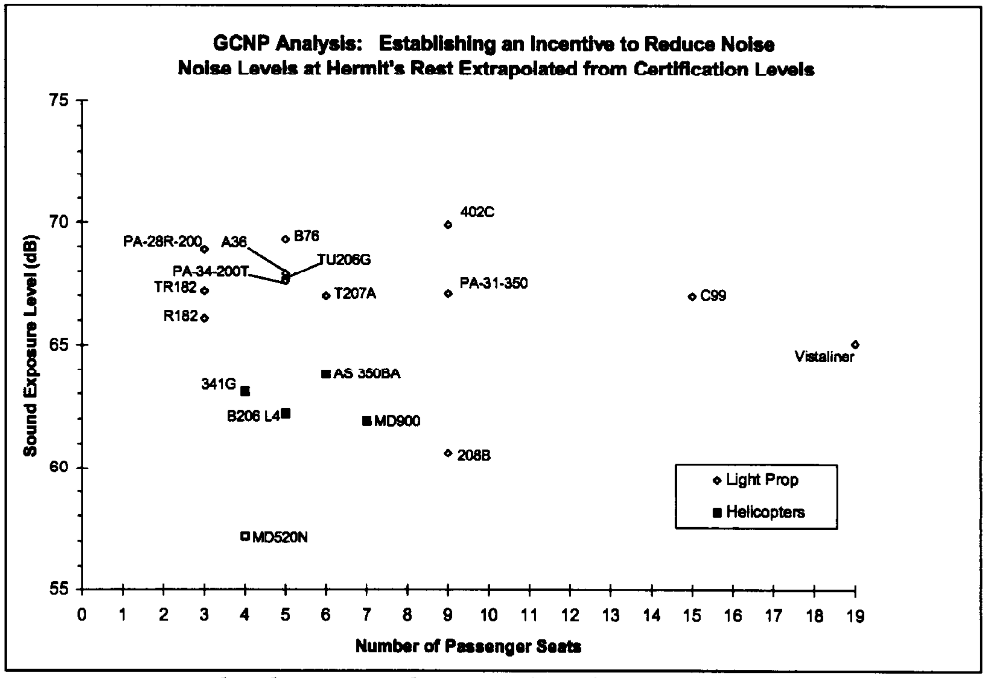

Figure 4. Extrapolated Noise Levels vs. Number of Passenger Seats

Table 1. Aircraft Identities

Aircraft Identity	Make, Model, and Popular Name
Airplanes	
207A	Cessna 207A Skywagon
208B	Cessna 208B Caravan I
402C	Cessna 402C Business Liner
A36	Beech A36 Bonanza
B76	Beech B76 Duchess
C99	Beech C99 Airliner
PA-28R-200	Piper PA-28R-200 Arrow II
PA-31-350	Piper PA-31-350 Chieftain
PA-34-200T	Piper PA-34-200T Seneca II
R182	Cessna R182 Skylane RG
T207A	Cessna T207A Turbo-Skywagon
TR182	Cessna TR182 Turbo-Skylane RG
TU206G	Cessna TU206G Turbo-Stationair
Vistaliner	DeHavilland DHC6-300 w/ Raisbeck propeller
Helicopters	
341G	Aerospatiale 341G Gazelle
AS 350BA	Aerospatiale AS 350BA Ecureuil/Astar
B206 L4	Bell B206 L4 Longranger IV
MD520N	McDonnell Douglas MD520N NOTAR
MD900	McDonnell Douglas MD900 MDX

The NPS report to Congress[3] identifies the DHC-6-300 Twin Otter ("Vistaliner" version), the Cessna Caravan I, and the McDonnell Douglas "No Tail Rotor"

[3] Report of DOI/NPS to the U.S. Congress Pursuant to Pub. L. 100-91, "Reports on Effects of Aircraft Overflights on the National Park System," July 1995.

(NOTAR) helicopters as the quietest aircraft currently operating at GCNP. The report further states that NPS expects that these aircraft would qualify under a "quiet aircraft" category. Figure 4 supports the NPS finding as the noise levels of the Vistaliner, Caravan (C208A), and the NOTAR helicopters (MD520 and MD900) are lower than other air tour aircraft. The relative locations of these "quiet aircraft" on the chart also reveal a break or gap with the other aircraft. Figure 5 contains the same information as Figure 4 with the addition of a demarcation between the quietest aircraft and the rest of the air tour fleet. The two components of the line are: (1) horizontal until greater than 2 passenger seats, and (2) increasing slope at 3 dB per doubling of number of seats. The line is horizontal until the number of seats is greater than 2 because a review of aircraft specification data found that two is the fewest number of passenger seats found on an aircraft that had operated as an air tour aircraft in GCNP. Specifying a limit that increases with number of seats is consistent with FAA's philosophy of rewarding efficiency by allowing aircraft which carry more passengers to emit more noise, thus creating less noise per passenger. For example, the slope of Appendix H noise limit increases at the rate of 3 decibels per doubling of weight. For aircraft in these weight ranges, 3 dB per doubling of number of seats is a comparable growth rate to 3 dB per doubling of weight.

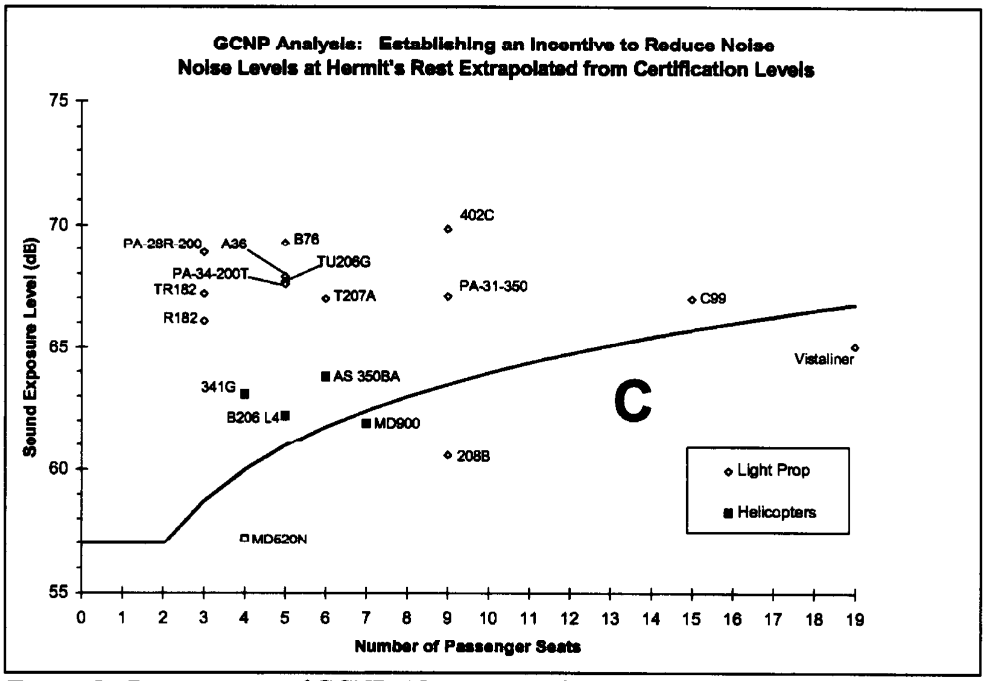

Figure 5. Demarcation of GCNP "Quiet Aircraft"

The area below the line in Figure 5 is proposed as the potential objective in the encouragement of compatible noise abatement technology for air tour operations in GCNP. For reasons that are set forth below, this area is labeled "C" and the aircraft whose SELs fall within this region are "GCNP Category C aircraft." Except for the Piper PA-28R-200, all the air tour aircraft above the line fall within 8 decibels of the line. Plotting another line at 4 decibels above the line in Figure 5 will not only create two new areas each covering 4 decibels but will evenly split the number of air tour aircraft into these two zones. Figure 6 shows the additional line and also labels the two new areas "A" and "B." Aircraft whose noise levels fall within these new zones are identified as GCNP Category A and GCNP Category B aircraft, respectively. An examination of a recent count of air tour aircraft finds that there are 57 GCNP Category A aircraft, 56 GCNP Category B, and 23 GCNP Category C aircraft operating at GCNP.

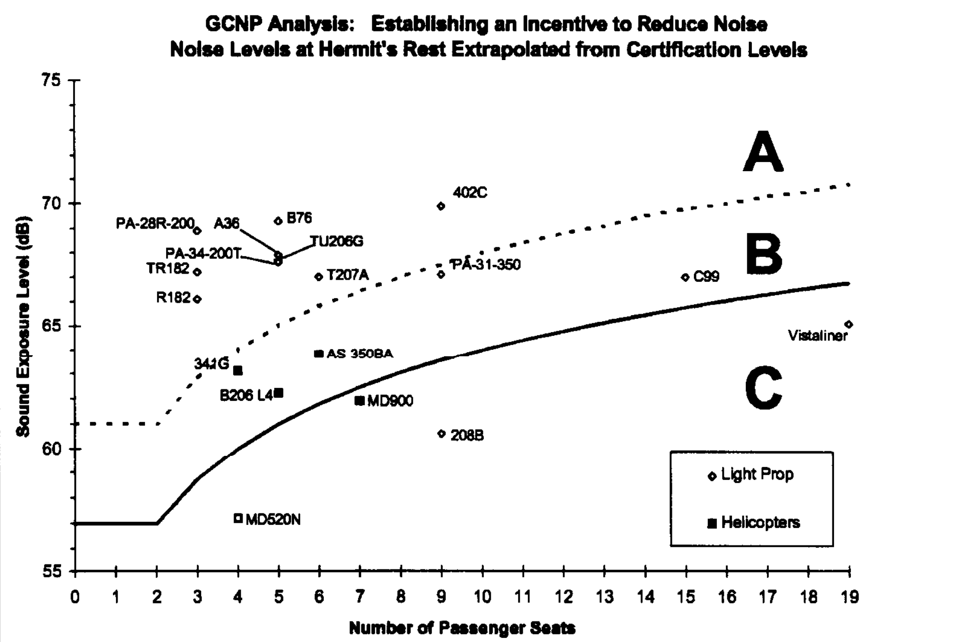

Figure 6. Bases for GCNP Noise Efficiency Criteria

Noise Efficiency Criteria

Figure 6 displays the technical foundation for a noise efficiency concept that has 4 of the 5 desired attributes. The noise data are based upon certificated noise levels that have been extrapolated to a common noise sensitive reference point in GCNP for direct comparison of airplanes and helicopters. The curves in Figure 6 demonstrate the general concept and are the bases for the noise efficiency criteria. The data presented on Figure 6 form one of the last building blocks toward establishing workable criteria for certification noise levels obtained under Appendices F, G, H, and J of 14 CFR part 36. The criteria should be easy to apply and manage in the field and should be understandable to the operators and general public. The airport community has many years of experience using the certificated noise levels published in FAA's AC 36-1. These data have been used to establish use restrictions, curfews, and noise budgets at some airports in the country. The certificated noise levels are not only available in advisory circulars which are updated and published periodically but the levels are readily available to the aircraft owners from the aircraft flight manuals (AFM). Thus the development of noise efficiency criteria based on certificated noise levels is proposed not only because of the precedent, but it also eliminates the need for someone in the field to perform the mathematical extrapolations from certification to GCNP conditions which were described in the two earlier sections.

To translate the two criteria lines shown in Figure 6 to the appropriate certification levels under 14 CFR part 36 is simply a matter of reversing the process which was used to determine the levels shown in Figures 4-6. Since the extrapolated noise levels were derived from three different sets of certificated noise data, Appendices F, H, and J, the reverse extrapolations will produce the GCNP noise efficiency criteria for Appendices F, H, and J. These are shown in Figures 7a, 7b, and 7c, respectively. The figures also contain the equations for the GCNP Categories B and C noise efficiency criteria or noise limits. These are the criteria for compliance with the proposed regulation.

As stated earlier, this study did not discover a method to successfully extrapolate Appendix G noise levels to GCNP conditions. When FAA promulgated Appendix G to supersede Appendix F, the change was to replace the level flyover test with a takeoff test. The Appendix G noise limit is 5 decibels higher than the Appendix F noise limit to account for difference in measured noise levels obtained under the different test conditions. Applying that philosophy to this situation, a noise efficiency criterion for Appendix G noise levels can be derived by adding 5 decibels to the criteria for Appendix F. There is no figure in this paper, similar to Figures 7a-c, showing the Appendix G noise efficiency criteria because all of the propeller-driven airplanes currently operating at GCNP predate the promulgation of Appendix G of 14 CFR part 36. The equations of the noise efficiency criteria for Appendix G are found in the next section.

Proposed GCNP Noise Limits

For the purpose of significantly reducing noise impact in GCNP, the information presented in Figures 7a-c would become noise limits for the air tour operators. The limits would be expressed as follows:

GCNP Category B Noise Limit

1. For helicopters with a flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix H of part 36, the limit is 84 dB for helicopters having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for helicopters having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$\mathbf{EPNL_{(H\text{-}Cat\ B)} = 84 + 10\log(\#\ PAX\ seats/2)\ dB}$$

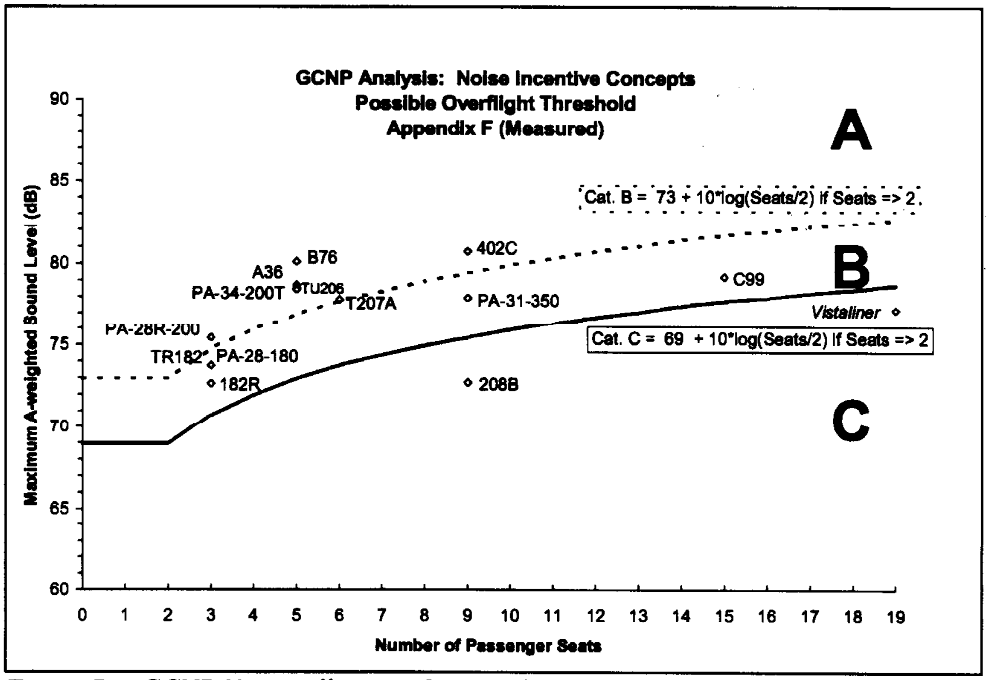

Figure 7a. GCNP Noise Efficiency Criteria for Appendix F Noise Levels

Proposed GCNP Noise Limits (continued)

GCNP Category B Noise Limit (continued)

2. For helicopters with a flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix J of part 36, the limit is 81 dB for helicopters having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for helicopters having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$SEL_{(J\text{-}Cat\ B)} = 81 + 10\log(\#\ PAX\ seats/2)\ dB$$

3. For propeller-driven airplanes with a measured flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix F of part 36 without the performance correction defined in Sec. F35.201(c), the limit is 73 dB for airplanes having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for airplanes having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$L_{Amax(F\text{-}Cat\ B)} = 73 + 10\log(\#\ PAX\ seats/2)\ dB$$

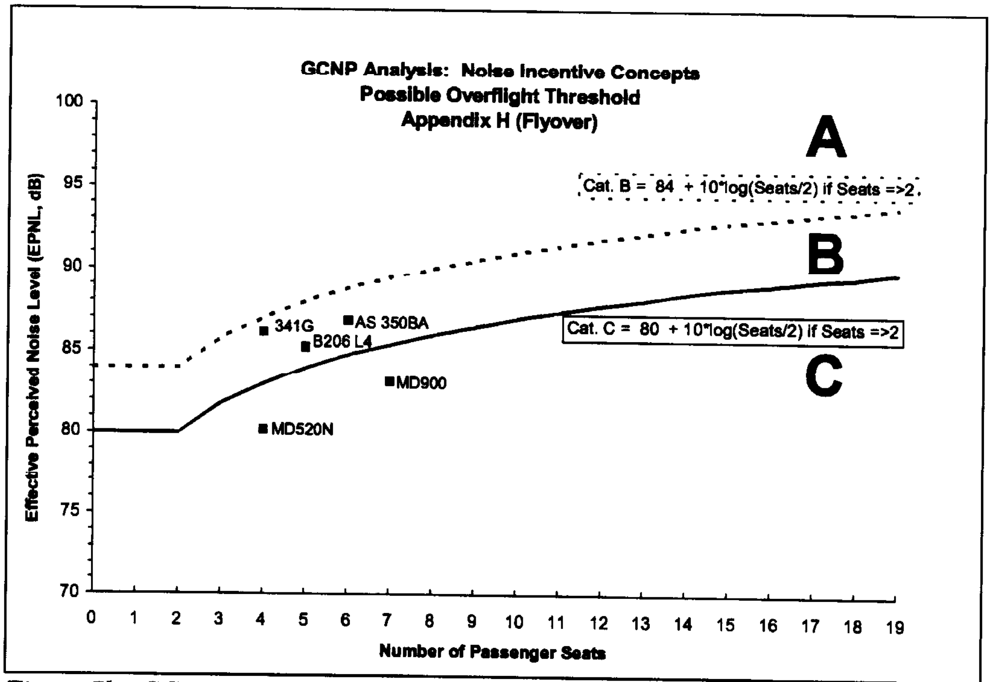

Figure 7b. GCNP Noise Efficiency Criteria for Appendix H Noise Levels

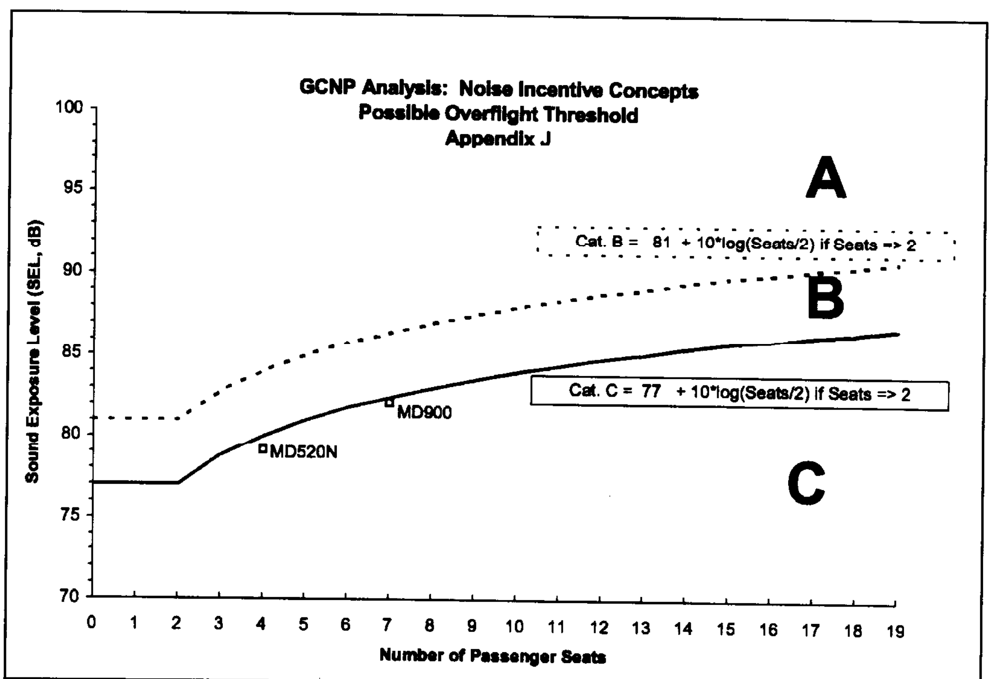

Figure 7c. GCNP Noise Efficiency Criteria for Appendix J Noise Levels

GCNP Category B Noise Limit (continued)

4. In the event that a flyover noise level is not available in accordance with Appendix F of part 36, the noise limit for propeller-driven airplanes with a takeoff noise level obtained in accordance with the measurement procedures prescribed in Appendix G is 78 dB for airplanes having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for airplanes having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$L_{Amax(G\text{-}Cat.\ B)} = 78 + 10\log(\#\ PAX\ seats/2)\ dB$$

GCNP Category C Noise Limit

1. For helicopters with a flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix H of part 36, the limit is 80 dB for helicopters having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for helicopters having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$EPNL_{(H\text{-}Cat.\ C)} = 80 + 10\log(\#\ PAX\ seats/2)\ dB$$

2. For helicopters with a flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix J of part 36, the limit is 77 dB for helicopters having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for helicopters having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$SEL_{(J\text{-}Cat.\ C)} = 77 + 10\log(\#\ PAX\ seats/2)\ dB$$

3. For propeller-driven airplanes with a measured flyover noise level obtained in accordance with the measurement procedures prescribed in Appendix F of part 36 without the performance correction defined in Sec. F35.201(c), the limit is 69 dB for airplanes having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for airplanes having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$LAmax_{(F\text{-}Cat.\ C)} = 69 + 10\log(\#\ PAX\ seats/2)\ dB$$

4. In the event that a flyover noise level is not available in accordance with Appendix F of part 36, the noise limit for propeller-driven airplanes with a takeoff noise level obtained in accordance with the measurement procedures prescribed in Appendix G is 74 dB for airplanes having 2 or fewer passenger seats, increasing at 3 decibels per doubling of the number of passenger seats for airplanes having 3 or more passenger seats. The limit at number of passenger seats of 3 or more can be calculated by the formula:

$$LAmax_{(G\text{-}Cat.\ C)} = 74 + 10\log(\#\ PAX\ seats/2)\ dB$$

Implementation

The proposed GCNP aircraft noise efficiency concept links to the aircraft noise certification provisions prescribed in 14 CFR part 36. The incentive criteria will be based upon the noise levels obtained under noise certification conditions. The use of noise certification levels will provide an ability to judge fixed- and rotary-wing aircraft on a common basis.

New aircraft are subject to the provisions of 14 CFR part 36 including the requirement to conduct a noise certification test under controlled conditions. This test is conducted in accordance with an FAA approved test plan and is typically witnessed by FAA personnel unless delegated to an FAA designee. Some aircraft, depending on the date of type certification, were not subject to the noise certification provisions of 14 CFR part 36. Thus noise certification levels are non-existent. In the strict sense certification noise tests should be required to establish noise levels for comparative purposes against the GCNP aircraft noise efficiency criteria.

The FAA does not have the authority to mandate that those older aircraft conduct such tests for compliance with the provisions of 14 CFR part 36. However, in order to fully implement the GCNP aircraft noise incentive concept, noise certification levels or estimates of those levels under certification conditions will be required.

Considering the overall cost associated with conducting noise certification tests and establishing noise certification levels it is proposed to offer a hierarchy of noise level data source options for establishing noise levels to fully implement the GCNP aircraft noise incentive concept. FAA plans to publish an Advisory Circular (AC 36-XX) that will facilitate the determination of the noise levels for GCNP noise efficiency criteria. This AC would list all aircraft operating at GCNP as determined from operations specifications. Noise levels would be specified for each aircraft listed in the AC.

In some cases the noise levels listed in this proposed AC would be the actual FAA approved noise certification levels documented in the FAA approved airplane or rotorcraft flight manuals. These levels are typically provided in FAA AC 36-1 and would simply be referenced in the proposed GCNP AC. In other cases where noise certification under 14 CFR part 36 was not required the noise level could be provided to the FAA by the operator or owner following the hierarchy described below. The owner or operator would have to substantiate to the FAA that the estimated noise level is representative for the subject aircraft.

The following hierarchy of noise level data sources would be documented in the proposed AC and used for all aircraft in determining the noise level for the GCNP aircraft noise incentive concept:

1. U.S. certifications under 14 CFR part 36 with noise certification levels obtained from the FAA approved flight manuals or FAA AC 36-1.
   a) For propeller driven small airplanes the applicable hierarchy of regulations is:
      1) 14 CFR part 36 Appendix F
      2) 14 CFR part 36 Appendix G

   a) For helicopters the applicable hierarchy of regulations is:
      1) 14 CFR part 36 Appendix J
      2) 14 CFR part 36 Appendix H

2. Foreign certifications under ICAO Annex 16, Volume I with noise certification levels obtained from the approved flight manuals, data approved by the foreign civil aviation authority, or FAA AC 36-1.
   a) For propeller driven small airplanes the applicable hierarchy of regulations is:
      1) ICAO Annex 16, Volume I Chapter 6
      2) ICAO Annex 16, Volume I Chapter 10
   a) For helicopters the applicable hierarchy of regulations is:
      1) ICAO Annex 16, Volume I Chapter 11
      2) ICAO Annex 16, Volume I Chapter 8

3. Research or other measurement test data obtained under controlled conditions, documented and corrected to the certification conditions of Appendix F for small propeller driven airplanes and Appendix J for helicopters. Preference would be placed on those data obtained under certification-like conditions or those data collected under an FAA sponsored noise research test.

4. FAA approved noise estimation methods that can estimate Appendix F noise levels for small propeller driven airplanes and Appendix J noise levels for helicopters. Currently the following methods may be suitable for use pending FAA approval on a case by case basis.
   a) For propeller driven small airplanes: Method in Section 2.2 of DOT/FAA/AEE-82-1
   b) For helicopters: SAE/AIR 1989

As one moves down on the hierarchy the expected level of substantiation (as the representative noise certification level-estimated) by the operator or owner would increase, and the level of FAA scrutiny should be expected to increase.

The resulting noise levels will vary depending upon an operator's or owner's situation related to the above hierarchy. In the case of helicopters the noise levels will be the flyover noise certification level in the noise metric of Effective Perceived Noise Level (14 CFR part 36, Appendix H) or Sound Exposure Level (14 CFR part 36, Appendix J). In the case of small propeller-driven airplanes the noise levels will be the flyover (14 CFR part 36, Appendix F) or takeoff (14 CFR part 36, Appendix G) noise certification level in the noise metric of maximum A-weighted sound level.

All estimated noise certification levels provided in the proposed FAA AC 36-XX would be for the sole and specific purpose of determining compliance with GCNP noise efficiency criteria.